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AIR QUALITY THUNDER BAY

Annual Report, 1977

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AIR QUALITY

THUNDER BAY

Annual Report, 1977

TECHNICAL SUPPORT SECTION
NORTHWESTERN REGION
ONTARIO MINISTRY OF THE ENVIRONMENT

June, 1978

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SUMMARY

The Ontario Ministry of the Environment has conducted air quality assessment investigations in Thunder Bay since 1963. This report presents results of the 1977 programme, which included measurements of particulate and gaseous pollutants throughout the city, as well as special surveys near selected local industries.

Although average dustfall levels in 1977 exceeded the Ontario air quality objective at four of 15 sites, the average for all sites in the city was lower than that for 1976. There has been a satisfactory trend of declining dustfall levels in recent years, with averages for 1977 being about a third lower than those recorded in 1973. Suspended particulate concentrations have also shown a substantial decrease of about 30 percent for the same 5-year period. Levels of heavy metals in suspended particulate were consistently below the maximum values permitted under Ontario regulations. Soiling index, monitored at two sites, was also well within provincial objectives.

Sulphation rates, which estimate average levels of sulphur-containing gases, were within the air quality objective at all sites in the city. Sulphur dioxide concentrations, monitored continuously at seven locations, were also below maximum acceptable limits for all but two hours of the year. No excursions above the daily or annual objectives were recorded. Severe sulphur dioxide vegetation injury was, however, documented following a sulphur fire in late May. Damaged vegetation showed good recovery later in the growing season. Concentrations of total reduced sulphur at a monitoring station near Great Lakes Paper Limited occasionally were above the Ontario guideline.

INTRODUCTION

The Ontario Ministry of the Environment, and its predecessor agencies, have conducted air quality assessment investigations in Thunder Bay since 1963. Earlier reports (1, 2) have documented the results of these investigations up to 1976. In 1977, the Ministry's programme continued with little change from 1976. One additional instrument to measure soiling index was installed, and the number of monitoring points for dustfall and sulphation rate was slightly increased. The 1977 network included 15 dustfall jars, 6 high-volume suspended particulate samplers, 2 soiling index monitors, 12 sulphation plates, and continuous monitors for total reduced sulphur (1 instrument) and sulphur dioxide (2 instruments). An additional 5 sulphur dioxide analysers were operated by Ontario Hydro.

Special air quality surveys were carried out during the year near specific Thunder Bay industries. These included the Abitibi and Great Lakes Paper pulp mills, and the Thunder Bay Terminals project on McKellar Island. This report contains brief summaries of these special studies, each of which is fully described in separate reports.

PARTICULATE POLLUTANTS

DUSTFALL

Dustfall, one of the most visible kinds of air pollutants, consists of particulate matter which settles out from the atmosphere by gravity. It is measured by exposing open-top plastic jars to the air for 30 days and weighing the collected matter. Specific components of dustfall may also be determined by chemical analysis or microscopic examination. Results are normally expressed in

g/m^2 (grams per square metre) for 30 days. The Ontario air quality objectives for total dustfall are 7 g/m^2 for 30 days and 4.6 g/m^2 , annual average. These values are equivalent to 20 and 13 tons per square mile which were, respectively, the monthly and annual objectives in use before conversion to metric units in January, 1977. All routine dustfall analyses were performed in the Ministry's Thunder Bay laboratory.

Dustfall levels in 1977 are summarized in Table 1 for 15 sites whose locations are shown in Figure 1. The 30-day Ontario air quality objective was exceeded at least once at 7 of the 15 stations, but all except four sites were within the objective for annual average. Dustfall was generally greatest at locations near grain elevators. Since the quantity of sulphate in dustfall was consistently low (less than $1 \text{ g/m}^2/30$ days), individual sulphate levels have not been included in this report.

The insoluble portion of dustfall from four Thunder Bay monitoring sites was submitted to the Ministry's Toronto laboratory for microscopic examination. The volume percent was determined for each substance identified. Then, approximate figures for weight percent were obtained by assigning density values to the different substances encountered (3). Results are summarized in Table 2, which shows that grain dust was an important constituent of dustfall at two sites (stations 63024 and 63026) near grain elevators. Siliceous material was also prominent in dustfall, indicating that re-entrainment of dust blown from roads and other unpaved, dirt-covered areas accounted for a significant part of measured dustfall. Fly-ash, coke and wood char occurred at relatively low levels (each usually less than 10 percent of total dustfall). Miscellaneous substances (mainly biological matter) sometimes comprised a substantial fraction (10-15 percent) of total dustfall.

Average dustfall for 13 monitoring sites is compared in Table 3 for the 5-year period from 1973 to 1977. The averages in the table, which are plotted graphically in Figure 2, show a satisfactory declining trend in recent years. Since 1973, the average dustfall in the City of Thunder Bay has decreased about 33 percent, from 6.0 to 4.0 g/m². Further decreases in dustfall may be expected in 1978 as major dust emission control programmes reach completion at 14 grain elevators throughout the city. A comparison between dustfall in 1973 and 1977 (Figures 4a and 4b,) shows that dustfall levels in 1977 exceeded the Ontario air quality objective in only a few small areas near industrial activity.

Dustfall was highest in spring and summer, and lowest in autumn and winter. This situation is normal and has been observed before in Thunder Bay and other areas. With easterly prevailing winds, dustfall averaged 4.4 g/m², compared with 3.1 g/m² for westerly wind. Most monitoring sites are downwind of grain elevators when winds are from the east.

Compared with the most recently available data for other population centres in Ontario, Thunder Bay dustfall in 1977 was slightly higher than that in Sudbury, slightly lower than that in Sault Ste. Marie and much lower than dustfall levels in industrial cities such as Hamilton or Windsor.

SUSPENDED PARTICULATE

Suspended particulate constitutes particulate matter of small size which remains in the atmosphere for extended periods. Every sixth day, a measured volume of air is drawn through pre-weighed glass fibre filters for a 24-hour period. Filters are re-weighed after exposure to determine the quantity of dust collected. Results are expressed in µg/m³ (micrograms per cubic metre of

air). The Ontario air quality objectives for total suspended particulate (TSP) are $120 \mu\text{g}/\text{m}^3$, 24-hour average, and $60 \mu\text{g}/\text{m}^3$, annual geometric mean. In addition to TSP determinations, exposed filters from two Thunder Bay stations were analysed for nitrate, sulphate, and a range of heavy metals.

TSP concentrations for 1977 are presented in Table 4. The 24-hour objective of $120 \mu\text{g}/\text{m}^3$ was exceeded occasionally at 4 of the 6 sites, and frequently at station 63017. TSP levels at one station (63040) were all below the maximum acceptable level. Suspended particulate, like dustfall, has declined during the past 5 years. The data in Table 5 and Figure 3 show that average TSP concentrations have fallen over 30 percent from 1973 to 1977, from an average of $70 \mu\text{g}/\text{m}^3$ to an average of $48 \mu\text{g}/\text{m}^3$. Thunder Bay TSP levels in 1977 were much below comparable values for Windsor ($93 \mu\text{g}/\text{m}^3$), Hamilton (77), Toronto (73), Ottawa (61) and Sault Ste. Marie (60). Sudbury, at $40 \mu\text{g}/\text{m}^3$, had average values somewhat lower than those for Thunder Bay.

Like dustfall, TSP levels were highest in spring and summer, and lowest in autumn and winter. In relation to wind direction, high TSP concentrations were most frequently associated with easterly or southerly wind. Under these conditions, the six Thunder Bay monitors would be downwind of the principal sources of particulate emissions.

The concentrations of heavy metals, nitrates and sulphates are shown in Table 6 for suspended particulate at two downtown monitoring sites in Thunder Bay. As in former years, the levels of all of these pollutants were well below those prescribed in Ontario regulations. Nitrate and sulphate concentrations in TSP in Thunder Bay are among the lowest recorded in urban areas of Ontario (4).

SOILING INDEX

Soiling index is a measurement of the soiling or darkening properties of suspended particulate matter. A measured volume of air is continuously drawn through a circular area on a paper filter tape. The soiling properties of the suspended particulate matter deposited on the tape is determined by the reduction of light transmitted through the tape and is related to both the opacity and darkness of the deposit. Samples are taken automatically every 2 hours and the soiling index for each sample is expressed as coefficient of haze (COH) per 1000 linear feet of air sampled. The 24-hour Ontario air quality objective is 1.0 COH and the annual objective is 0.5 COH.

The 1977 soiling index data for stations 63022 and 63040 are summarized in Tables 7 and 8. For a limited sampling period at station 63022, the 24-hour maximum was 0.3 COH and the "annual" average was 0.19 COH, both well within regulations. The situation at station 63040 was similar, with a daily maximum of 0.4 and an annual average of 0.17. Results for 1976 were similar.

GASEOUS POLLUTANTS

SULPHATION RATE

Sulphation rates provide an indication of the presence of sulphur-containing gases in the air. They are determined by exposing small plastic dishes, coated with lead dioxide, to the atmosphere for 30-day periods. Lead dioxide combines with reactive sulphur compounds to form lead sulphate. The quantity of sulphate formed is analytically determined and reported as $\text{mg SO}_3/100 \text{ cm}^2/\text{day}$ (milligrams of sulphur trioxide per hundred square centimetres per day). Although the method is normally applied to estimate average sulphur dioxide concentrations, measurable sulphation

rates may also be obtained if other reactive gases are present. In most areas of Thunder Bay, sulphur dioxide is the principal contaminant reacting with the coated plates. However, near facilities such as sewage treatment plants or kraft pulp mills, reduced sulphur compounds may be present at concentrations high enough to produce measureable sulphation rates. The Ontario air quality objective of $0.7 \text{ mg SO}_3/100 \text{ cm}^2/\text{day}$ is related to long-term average sulphur dioxide concentrations.

Sulphation rates in 1977 at 12 sites in Thunder Bay are given in Table 9. All values were below the air quality objective, which indicates that at sites where sulphur dioxide was the only reactive pollutant, average sulphur dioxide levels were acceptable. Highest values were recorded at the Main Street sewage treatment plant, a local source of reduced sulphur emissions. The average values for the year were somewhat higher than earlier years (Table 10), possibly because of the substantially increased level of operations at the Ontario Hydro generating station on Mission Island. Power was generated every month at this plant in 1977, compared with about one and a half months in 1976. Sulphur dioxide emissions were therefore about 10,500 tons in 1977 in contrast with 1,500 tons the preceding year.

SULPHUR DIOXIDE

Sulphur dioxide (SO_2), one of the world's major atmospheric pollutants, has many well-documented adverse effects on human health, vegetation and property. Fuel combustion and industrial emissions are significant man-made sources of SO_2 . In Thunder Bay, the Ontario Hydro generating station is the largest potential source. Other known sources include the four sulphite pulp mills and assorted industrial power boilers. Total SO_2 emissions in the Thunder Bay area are estimated to be less than 100 tons daily, a relatively small discharge in comparison with those from large

thermal generating stations or major ore smelters. Ontario regulations specify that sulphur dioxide concentrations should not exceed 0.25 ppm (parts per million), averaged over one hour, 0.10 ppm (24-hour average) or 0.02 ppm (annual average).

In 1977, the Ministry operated two Philips SO₂ monitors in Thunder Bay. Ontario Hydro had five instruments of the same type at five other sites. A summary of the data from these seven units is contained in Tables 11 and 12. At the Ministry's stations, the maximum concentrations were 0.13 ppm (hourly average) and 0.02 (24-hour average). Both these and the annual average (0.002 ppm for both sites) were well below the maximum acceptable limits. Two excursions above the hourly objective were monitored by Ontario Hydro instruments: one of 0.28 ppm on April 11 at station 63041, and one of 0.30 ppm on May 8 at station 63023. The latter was attributed to emissions from the generating station, but the cause of the former could not be established with certainty. The daily and annual objectives were met at all of the Hydro monitoring sites.

An incident causing acute injury to vegetation was caused by emissions from a sulphur fire on the property of Valley Camp Limited. The fire, which burned for about 2½ hours on May 28, resulted in damage to many species of trees, shrubs, flowers and vegetable crops in an area of about 260 ha (hectares) in a residential part of Thunder Bay south (Figure 5). A number of complaints were submitted by local residents with respect to alleged health effects and vegetation injury. Because of the strong, gusty winds and cool temperatures which prevailed at the time of the fumigation, the distribution and severity of injury was quite variable. No injury symptoms were observed higher than 5 metres above ground. An unusual feature was damage to lawn grass, which appeared "bleached" about two or three days after the fire. However, recovery was rapid and the damaged tips of grass blades disappeared when lawns

were next cut. Subject to confirmation by an assessment survey in 1978, it is probable that no vegetation was permanently harmed.

REDUCED SULPHUR

Hydrogen sulphide (H_2S) and methyl mercaptan (CH_3SH) are principal components of a group of reduced sulphur compounds collectively known as "total reduced sulphur" (TRS). These compounds are associated with emissions from kraft pulp mills and produce offensive odours at very low concentrations. If exposed to higher levels, some people may experience temporary respiratory irritation, and vegetation may be injured. A tentative guideline of 27 ppb (parts per billion), hourly average, was recently established as the Ontario air quality objective for TRS in the vicinity of kraft pulp mills.

In 1977, TRS was monitored with a Philips model 9700 instrument at station 63046, about 1100 metres from the Great Lakes Paper Limited kraft mill. The data are summarized in Table 13 and in Figure 6. Concentrations of TRS exceeded the guideline on 17 occasions in 1977. An analysis of TRS readings and wind direction (Table 14) shows that virtually all the TRS was measured when the monitor was downwind of the pulp mill.

SPECIAL SURVEYS

ABITIBI

Vegetation assessment surveys conducted during the past three years revealed the sporadic occurrence of acute sulphur dioxide injury near Abitibi's sulphite pulp mills in Thunder Bay. Vegetation injury symptoms were found only near the Mission Mill in 1975. In 1976, no injury was recorded. In 1977, a small amount of vegetation damage was observed near the Provincial mill. In the two cases where injury was documented, it did not extend beyond company property.

Analysis of snow collected around the three mills in 1976 and 1977 showed that levels of calcium, chloride, sodium and sulphate were below established guidelines, and that none of the mills were significant sources of airborne emissions of any of these contaminants.

GREAT LAKES PAPER

In late 1977, a special survey with mobile monitoring equipment was carried out in the vicinity of Great Lakes Paper Limited to evaluate the ambient air concentrations of particulate and gaseous pollutants. Results of this study will shortly be available in a report to be issued by the Ministry's Air Resources Branch.

THUNDER BAY TERMINALS

Pre-operational air and water quality investigations have been undertaken by the Ministry in the vicinity of Thunder Bay Terminals Limited, a coal storage facility scheduled for completion in June 1978. Data from these studies, up to the end of 1976, have been discussed in a separate report (5). Information for 1977, which includes dustfall and suspended particulate measurements, as well as an experimental moss bag exposure experiment, will be evaluated and reported in the near future.

THUNDERBRICK LIMITED

A sampling survey in July, 1977, disclosed that fluoride concentrations were elevated in tree foliage near a brick plant in Rosslyn Village. The guideline for fluoride in vegetation was exceeded at several sites near the plant and foliar fluoride levels decreased with increasing distance from the emission source. No fluoride injury symptoms were observed on local vegetation. Further investigation is scheduled for 1978.

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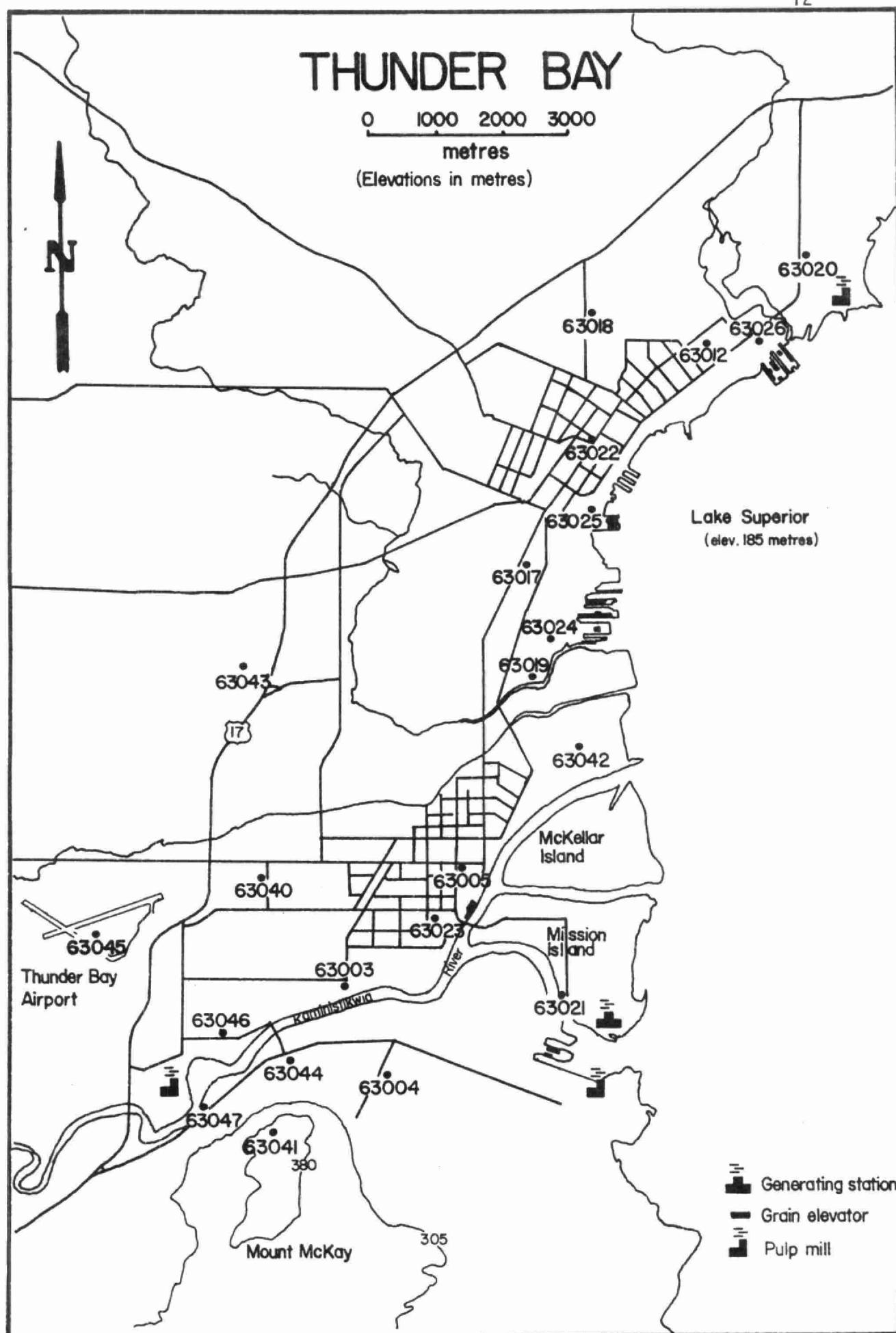


Figure 1. Air quality monitoring sites, 1977.

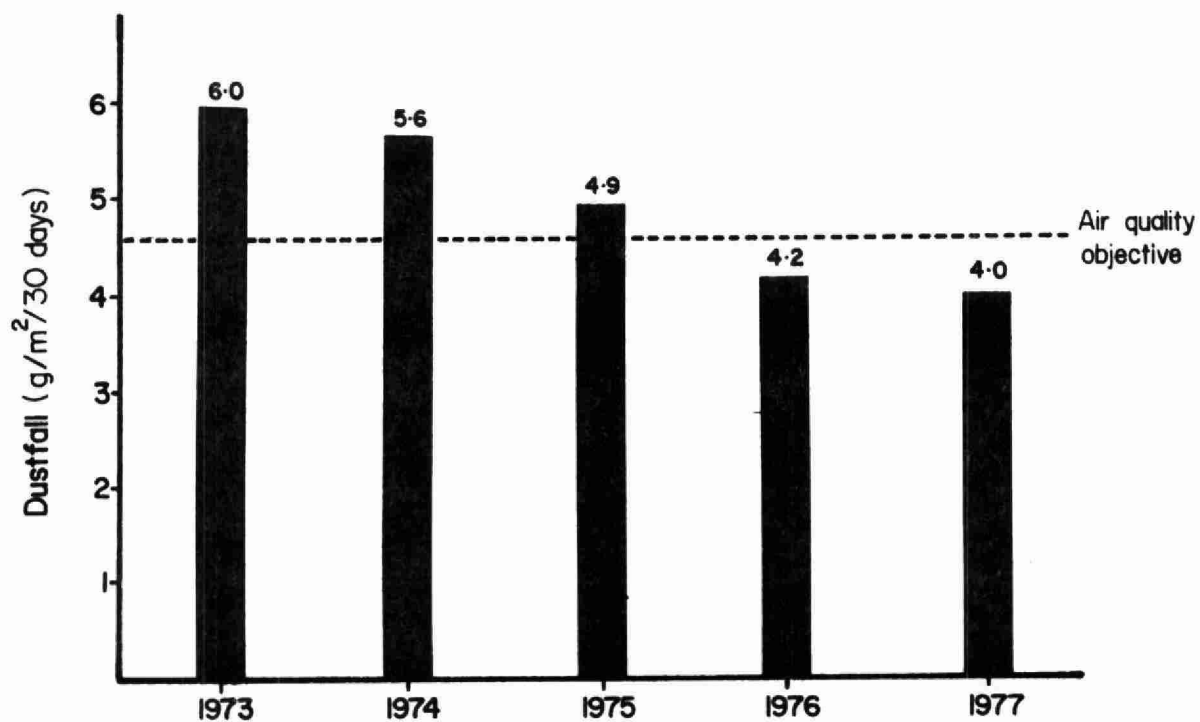


Figure 2. Average annual dustfall, 1973-1977, Thunder Bay.

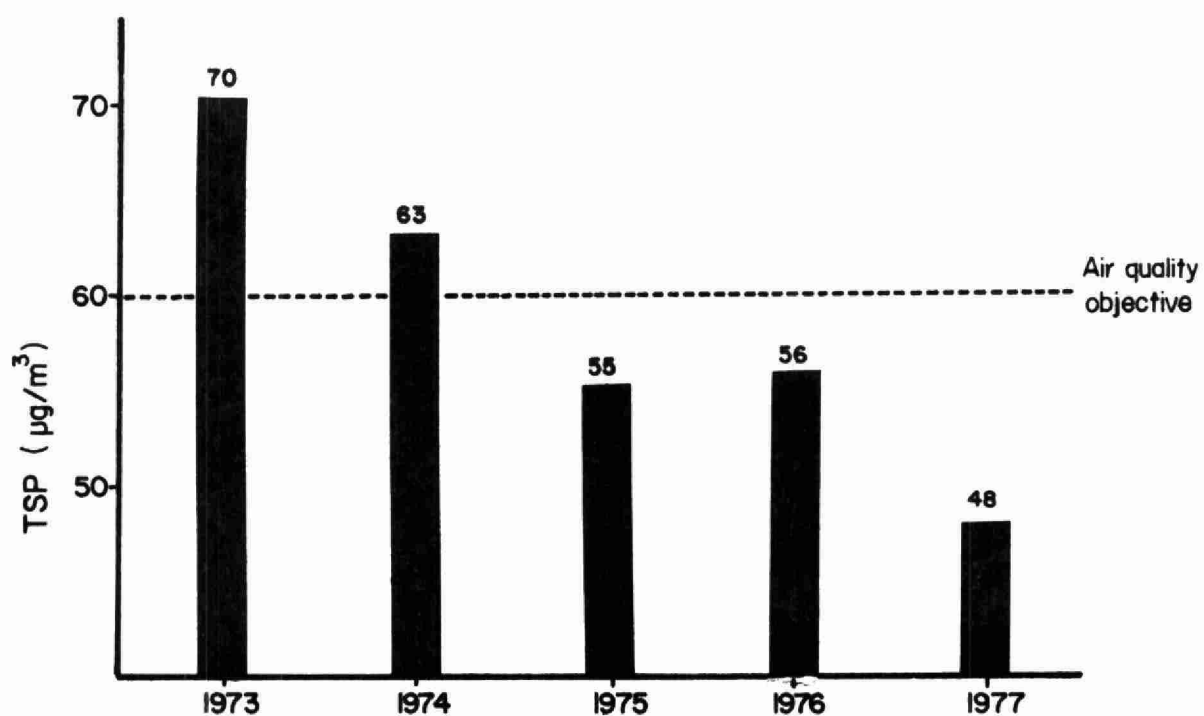


Figure 3. Average total suspended particulate (TSP), 1973-1977, Thunder Bay.

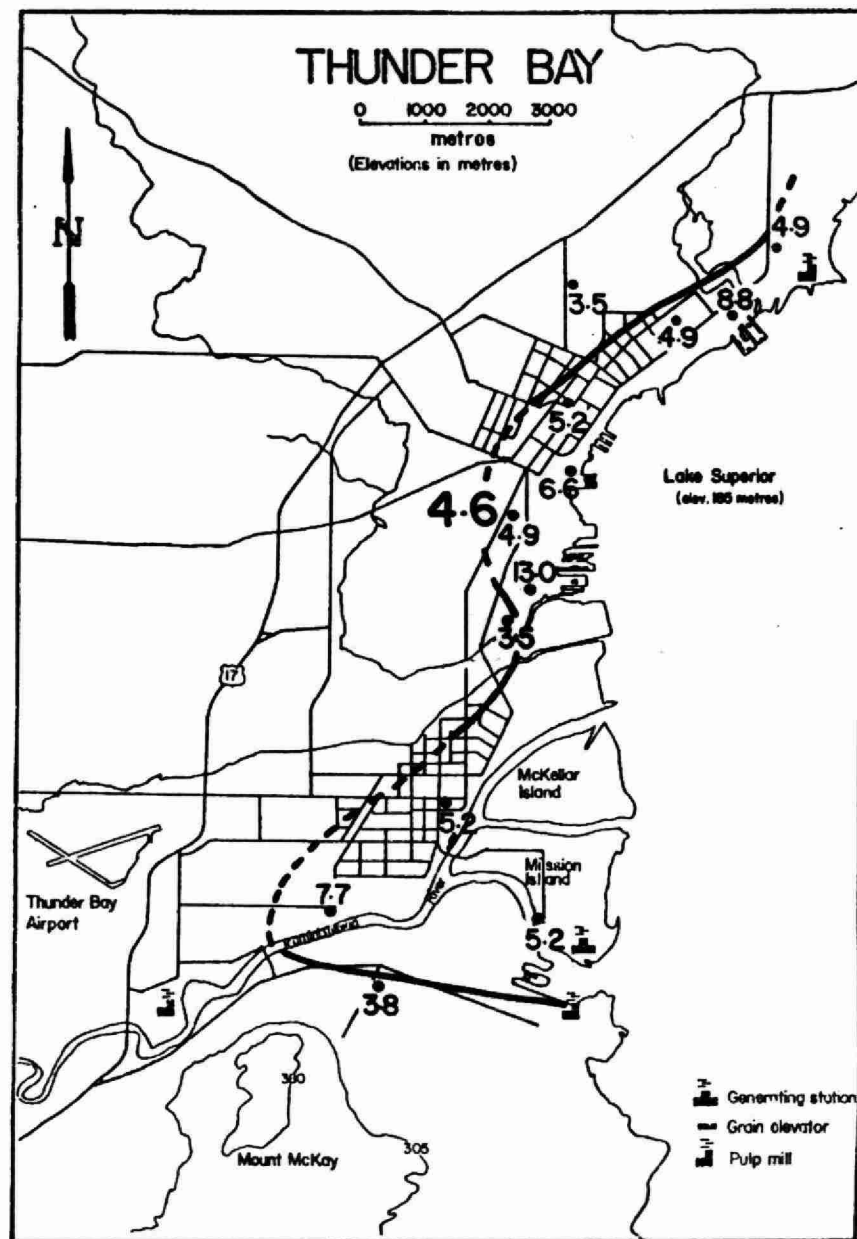


Figure 4 a. Average dustfall, 1973 ($\text{g}/\text{m}^2/30$ days).

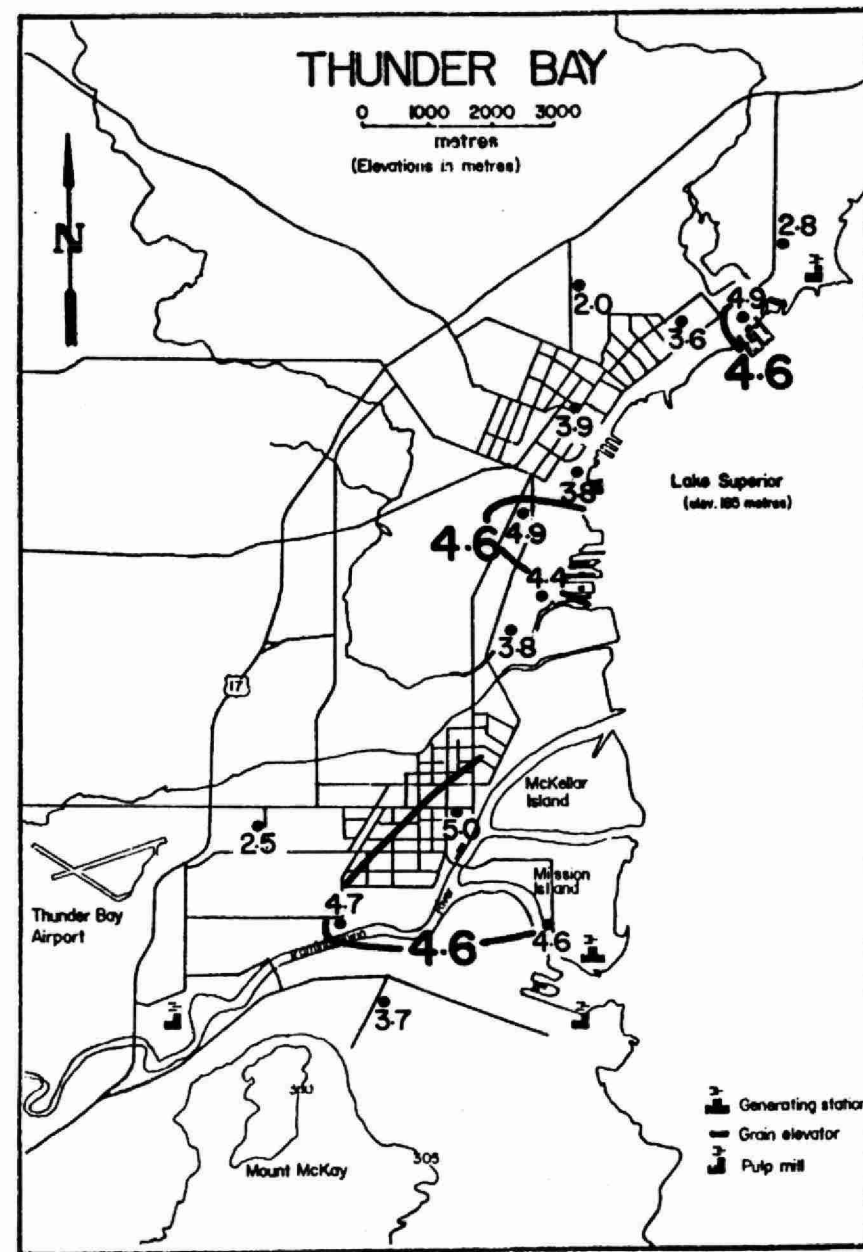


Figure 4 b. Average dustfall, 1977 ($\text{g}/\text{m}^2/30$ days).

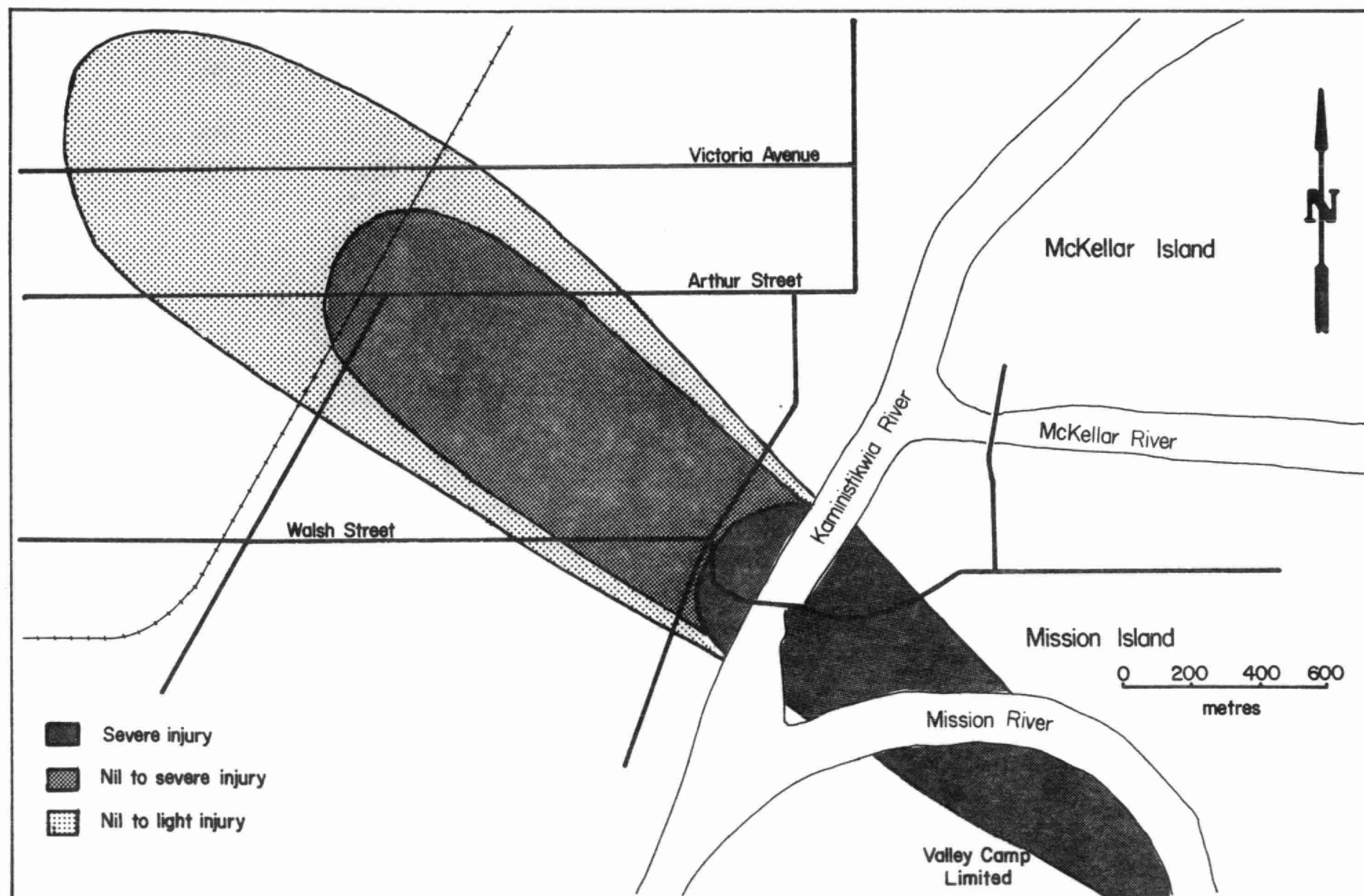


Figure 5. Sulphur dioxide vegetation injury caused by sulphur fire on May 28, 1977.

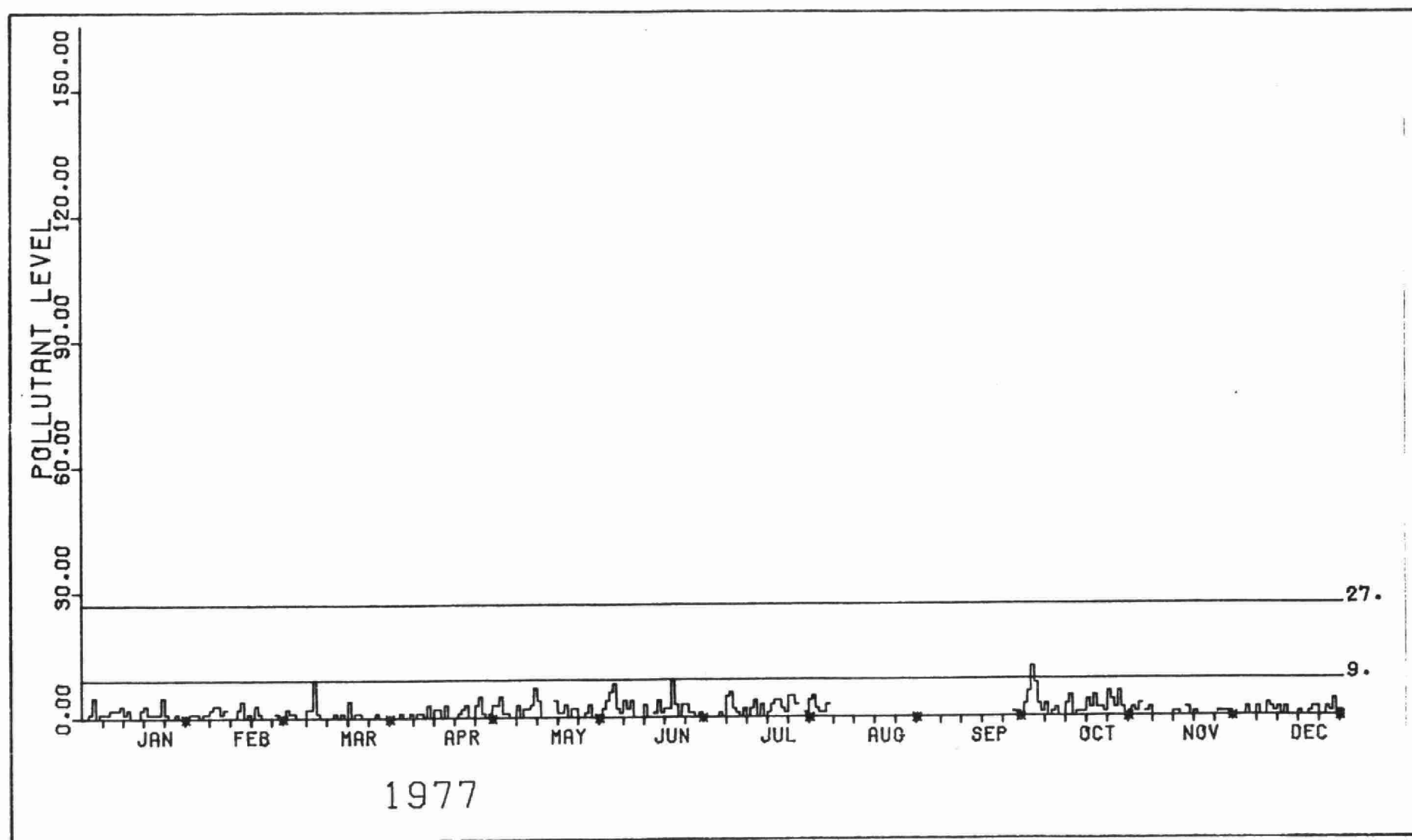


Figure 6. Daily mean TRS concentration (parts per billion), station 63046, Thunder Bay, 1977.

TABLE 1. Total dustfall, Thunder Bay, 1977.

Station	Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
63003	185 Gore Street	-	-	3.4	4.5	4.0	4.3	5.8	<u>7.6</u> ^a	<u>7.9</u>	3.9	3.4	2.4	<u>4.7</u>
63004	24 Mountain Road	2.6	1.6	3.0	<u>5.7</u>	3.4	3.0	4.6	5.1	6.8	2.3	3.1	3.5	3.7
63005	McKellar Hospital	1.1	5.8	5.5	<u>7.4</u>	6.2	<u>8.4</u>	5.4	3.9	3.8	2.8	4.0	6.0	<u>5.0</u>
63012	Dawson Court	1.0	2.2	5.8	-	5.0	3.3	4.0	4.2	4.5	3.4	3.7	2.7	3.6
63017	521 Memorial Avenue	1.0	-	4.9	6.7	4.3	5.0	6.0	5.2	6.4	4.6	6.9	2.7	<u>4.9</u>
63018	St. Ignatius School	0.4	0.9	2.6	2.4	3.4	1.5	3.0	-	-	2.0	2.5	0.8	2.0
63019	Main St. Sewage Plant	0.7	1.4	3.8	5.2	4.1	4.7	5.2	4.0	<u>7.4</u>	4.5	2.9	1.8	3.8
63020	Hodder Ave. Fire Hall	0.6	2.4	4.1	6.1	3.0	2.5	2.8	2.8	2.6	1.8	3.7	1.2	2.8
63021	Mission Island	6.5	5.1	4.6	3.3	3.6	3.3	2.5	6.6	-	3.2	4.2	<u>8.2</u>	4.6
63022	14 Algoma Street	0.7	1.7	6.2	6.4	6.2	2.9	5.0	3.1	3.4	3.5	4.0	1.1	3.7
63024	Hammond Ave./Inter-City	1.0	1.8	3.8	2.5	5.7	-	<u>13.9</u>	6.6	4.5	3.0	3.3	2.5	4.4
63025	Manitou Street	0.6	1.1	3.6	4.8	5.6	3.7	5.1	4.7	5.9	4.6	4.0	1.7	3.8
63026	North Cumberland Hydro	1.4	2.7	3.4	<u>7.8</u>	6.3	3.7	4.5	<u>10.5</u>	4.9	5.7	5.9	2.1	<u>4.9</u>
63040	435 James St. South	0.8	0.6	3.7	3.9	3.6	3.4	1.2	4.1	2.1	2.4	-	1.8	2.5
63047	Totem Trailer Court						5.5	-	4.6	6.8	4.2	6.8	<u>8.1</u>	

^aValues exceeding air quality objective of 7.0 (monthly) or 4.6 (annual average) are underlined.

TABLE 2. Insoluble dustfall composition (percent, by weight, of total dustfall) at four monitoring sites, Thunder Bay, 1977.

Station	Contaminant	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
63005	Grain dust	2	3	2	9	11	6	2	8	13	14	18		7
	Silica (eg. road dust)	27	39	42	38	10	26	57	20	16	29	35	63	34
	Fly-ash	5	4	< 1	13	10	5	4	10	8	4	8	7	6
	Coke		6	3	5	27	1	2	5	5	3	5	3	5
	Wood char	2			2		< 1							< 1
	Other ^a	9	19	10	12	18	31	7	23	32	3	2	8	14
63024	Grain dust	20	67	42	40	3	-		16	26	15	20	44	27
	Silica (eg. road dust)	7			6	27	-	35	8	3	14	16		11
	Fly-ash				10	8	-							2
	Coke	9	5		3	4	-	7	< 1	4	7	7	12	5
	Wood char	< 1	8	2	5		-			2	< 1			2
	Other		2	4	3	23	-	37	18	< 1	7	2		9
63026	Grain dust	21	30	42	70	64	41	27	80	54	76	54	64	52
	Silica (eg. road dust)		< 1	4	2	2	9	21	2		4	11	1	5
	Fly-ash				6	6	< 1	8				< 1		2
	Coke	< 1								3	< 1		1	< 1
	Wood char	6	3	4	< 1				< 1					1
	Other					4		4		< 1		3		< 1
63040	Grain dust	< 1	12	2	< 1	< 1		< 1	< 1	46	4	-		6
	Silica (eg. road dust)		5	23	4	17	38	7	38	16	14	-	32	18
	Fly-ash	< 1	67	3	2	7	14	2	7	9	3	-	10	11
	Coke					3	7	2	2	2	4	-		2
	Wood char					4	1	< 1		4	2	-		< 1
	Other	1		21	1	24	2	4	11	13	31	-	24	12

^aIncludes components such as biological matter (eg. pollen), tar, miscellaneous metals, coal.

TABLE 3. Average dustfall ($\text{g/m}^2/30$ days), Thunder Bay, 1973-1977.

Station	Location	1973	1974	1975	1976	1977	Five-year Average
63003	185 Gore St.	<u>7.7</u> ^a	<u>7.4</u>	4.6	4.2	<u>4.7</u>	5.7
63004	24 Mountain Road	3.9	3.9	3.5	3.2	3.7	3.6
63005	McKellar Hospital	<u>5.3</u>	<u>5.3</u>	<u>4.9</u>	3.5	<u>5.0</u>	4.8
63012	Dawson Court	<u>4.9</u>	4.6	3.5	3.5	3.6	4.0
63017	521 Memorial Ave.	<u>4.9</u>	<u>6.0</u>	<u>5.3</u>	<u>4.9</u>	<u>4.9</u>	5.2
63018	St. Ignatius School	3.5	3.5	2.5	3.2	2.0	2.9
63019	Main St. Sewage Plant	3.5	<u>7.0</u>	3.5	4.2	3.8	4.4
63020	Hodder Ave. Fire Hall	<u>4.9</u>	<u>5.3</u>	<u>5.6</u>	3.5	2.8	4.4
63021	Mission Island	<u>5.3</u>	<u>5.3</u>	<u>6.7</u>	<u>5.6</u>	4.6	5.5
63022	14 Algoma Street	<u>5.3</u>	<u>5.6</u>	4.2	3.9	3.7	4.5
63024	Hammond Ave./Inter-City	<u>13.0</u>	<u>10.2</u>	<u>7.7</u>	<u>5.3</u>	4.4	8.1
63025	Manitou Street	<u>6.7</u>	4.6	4.6	3.9	3.8	4.7
63026	North Cumberland Hydro	<u>8.8</u>	<u>6.7</u>	<u>6.0</u>	<u>5.6</u>	<u>4.9</u>	6.4
Average, all stations		6.0	5.6	4.9	4.2	4.0	
Stations exceeding criterion (%)		77	69	46	31	31	

^aValues exceeding air quality objective of 4.6 (annual average) are underlined.

TABLE 4. Total suspended particulate ($\mu\text{g}/\text{m}^3$), Thunder Bay, 1977.

Date		Stations					
		63005	63012	63017	63018	63022	63040
January	1	13	11	13	11	15	-
	7	14	15	19	12	15	18
	13	45	57	52	41	51	52
	19	52	49	48	-	48	53
	25	21	16	31	19	22	19
	31	-	18	21	9	20	-
February	6	38	20	49	20	34	22
	12	21	19	38	15	18	22
	18	36	18	75	15	19	20
	24	23	16	22	14	22	17
March	2	28	20	49	22	31	23
	8	92	86	107	78	95	97
	14	96	40	78	36	70	49
	20	-	37	105	32	53	25
	26	45	53	63	53	103	76
April	1	95	-	68	47	63	55
	7	63	50	128 ^a	41	56	82
	13	91	-	124	57	89	61
	19	32	90	55	37	61	45
	25	157	89	146	59	84	71
May	1	116	104	159	152	83	-
	7	61	-	130	62	61	30
	13	132	-	176	262	197	102
	19	93	95	109	31	-	47
	25	88	133	118	83	103	67
	31	120	125	182	89	-	85
June	6	88	36	151	37	66	51
	12	48	25	-	32	29	30
	18	22	42	52	15	29	17
	24	91	85	178	82	100	69
	30	65	89	107	43	94	63

(continued)

TABLE 4. (continued)

Date		Stations					
		63005	63012	63017	63018	63022	63040
July	6	49	104	<u>135</u>	53	<u>130</u>	48
	12	-	47	<u>67</u>	-	<u>47</u>	44
	18	<u>23</u>	87	117	59	<u>132</u>	88
	24	<u>37</u>	33	59	25	<u>44</u>	30
	30	29	27	38	18	30	19
August	5	39	32	64	27	41	29
	11	42	29	73	-	45	41
	17	30	19	-	18	22	19
	23	28	21	77	20	35	25
	29	46	66	104	50	64	-
September	4	36	37	44	18	53	24
	10	-	23	-	29	48	18
	16	63	73	97	64	104	79
	22	58	113	55	30	67	60
	28	54	80	106	35	58	24
October	4	<u>41</u>	106	<u>176</u>	88	120	26
	10	<u>37</u>	31	<u>56</u>	-	30	33
	16	59	25	44	38	33	35
	22	45	26	-	54	38	36
	28	94	110	<u>186</u>	<u>149</u>	<u>134</u>	85
November	3	79	71	<u>170</u>	49	70	53
	9	35	49	<u>38</u>	24	98	29
	15	72	84	80	47	-	36
	21	41	47	108	66	57	-
	27	23	31	50	25	40	51
December	3	24	13	34	18	-	8
	9	14	11	18	5	12	15
	15	32	31	45	24	61	82
	21	14	9	16	8	12	10
	27	36	26	59	23	36	23
Annual geometric means:		47	40	<u>69</u>	34	49	37

^aValues above air quality objectives of 120 $\mu\text{g}/\text{m}^3$ (24-hour average) and 60 $\mu\text{g}/\text{m}^3$ (annual geometric mean) are underlined.

TABLE 5. Average suspended particulate (annual geometric means, $\mu\text{g}/\text{m}^3$) in Thunder Bay, 1973-1977.

Station	Location	1973	1974	1975	1976	1977	Five-year Average
63005	McKellar Hospital	<u>69</u> ^a	<u>61</u>	51	49	47	55
63012	Dawson Court	59	51	47	47	40	49
63017	521 Memorial Avenue	<u>107</u>	<u>102</u>	<u>85</u>	<u>82</u>	<u>69</u>	89
63018	St. Ignatius School	40	40	36	37	34	37
63022	14 Algoma Street	<u>74</u>	60	55	<u>66</u>	49	61
Average, all stations		70	63	55	56	48	

^aMeans above annual air quality objective of $60 \mu\text{g}/\text{m}^3$ are underlined.

TABLE 6. Concentrations ($\mu\text{g}/\text{m}^3$, 24-hour average) of heavy metals, nitrate and sulphate in 55 samples of suspended particulate matter at stations 63005 and 63022, Thunder Bay, 1977.

Contaminant	63005		63022	
	Range	Average	Range	Average
Cadmium	ND ^a - <0.01	<0.01	ND - <0.01	<0.01
Chromium	ND - <0.01	<0.01	ND - 0.01	<0.01
Copper	0.02 - 0.11	0.05	0.01 - 0.08	0.03
Iron	0.08 - 7.40	2.00	ND - 7.90	2.10
Lead	0.11 - 0.77	0.30	0.12 - 1.60	0.46
Manganese	<0.01 - 0.11	0.04	<0.01 - 0.19	0.05
Nickel	ND - 0.03	<0.01	ND - 0.02	<0.01
Nitrate	0.40 - 9.60	1.50	0.03 - 8.90	1.40
Sulphate	1.50 - 9.50	4.90	0.70 - 10.40	5.10
Vanadium	ND - 0.06	<0.01	ND - 0.30	0.01
Zinc	ND - 1.48	0.35	ND - 0.70	0.22

^aNot detectable.

TABLE 7. Distribution of soiling index readings (2-hour averages) at station 63022, Thunder Bay, 1977.

Month	Days of data	Number of readings for ranges ^a of:			Maximum values	
		0.0-0.4	0.5-1.0	>1.0	24-hour	2-hour
October	7	82	8	0	3	9
November	30	333	27	0	3	9
December	3	35	3	0	3	9
Year	40	450	38	0	3	9

^aSoiling index = coefficient of haze per 1000 feet of air sampled.

TABLE 8. Distribution of soiling index readings (2-hour averages) at station 63040, Thunder Bay, 1977.

Month	Days of data	Number of readings for ranges ^a of:				Maximum values	
		0.0-0.4	0.5-1.0	1.1-1.5	>1.5	24-hour	2-hour
January	31	351	13	0	0	3	8
February	27	303	26	0	0	4	10
March	30	342	20	0	0	3	8
April	30	340	20	0	0	4	8
May	31	352	19	0	0	3	9
June	30	348	12	0	0	3	8
July	31	358	14	0	0	3	7
August	31	356	16	0	0	3	10
September	30	339	21	0	0	3	8
October	30	325	34	1	0	4	11
November	30	335	24	0	0	3	9
December	31	342	29	1	0	4	11
Year	362	4091	248	2	0	4	11

^aSoiling index = coefficient of haze per 1000 feet of air sampled.

TABLE 9. Sulphation rate (mg SO₃/100 cm²/day), Thunder Bay, 1977.

Station	Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
63003	185 Gore Street	.19	.09	.15	.10	.14	.07	.21	.04	.10	.08	.10	.17	.12
63004	24 Mountain Road	.17	.15	.19	.07	.19	.10	.15	.09	.10	.08	.13	.42	.15
63005	McKellar Hospital	.16	.09	.18	.07	.16	.10	.21	.09	.11	.08	.13	.12	.12
63012	Dawson Court	.13	.11	.25	.13	.27	.10	.21	.11	.26	.08	.18	.15	.16
63017	521 Memorial Avenue	.13	.09	.17	.11	.22	.10	.32	.11	.16	.09	.13	.14	.15
63018	St. Ignatius School	.13	.10	.19	.11	.21	.10	.15	.09	.15	.08	.12	.10	.13
63019	Main St. Sewage Plant	.14	.09	.17	.15	.21	.15	.55	.27	.67	.43	.40	.15	.28
63020	Hodder Ave. Fire Hall	.13	.08	.20	.09	.23	.09	.26	.14	.15	.13	.13	.10	.14
63021	Mission Island						.20	.37	.15	.17	.16	.19	.27	
63022	14 Algoma Street	.16	.16	.23	.15	.13	.13	.15	.09	.15	.08	.13	.23	.15
63040	435 James St. South	.09	.06	.27	.13	.21	.13	.26	.04	.15	.13	.16	.17	.15
63047	Totem Tourist Court						.13	.21	.11	.15	.24	-	.32	

TABLE 10. Average sulphation rates ($\text{mg SO}_3/100 \text{ cm}^2/\text{day}$) in Thunder Bay, 1973-1977.

Station	Location	1973	1974	1975	1976	1977	Five-year Average
63003	185 Gore Street	.07	.10	.13	.10	.12	.10
63004	24 Mountain Road	.16	.16	.18	.12	.15	.15
63005	McKellar Hospital	.09	.08	.09	.08	.12	.09
63012	Dawson Court	.11	.09	.08	.10	.16	.11
63017	521 Memorial Avenue	.10	.09	.10	.09	.15	.11
63018	St. Ignatius School	.07	.06	.07	.08	.13	.08
63019	Main Street Sewage Plant	.24	.11	.13	.15	.28	.18
63020	Hodder Avenue Fire Hall	.10	.10	.10	.08	.14	.10
63022	14 Algoma Street	.14	.12	.11	.10	.15	.12
Average, all stations		.12	.10	.11	.10	.16	

TABLE 11. Distribution of sulphur dioxide readings (pphm, hourly averages) in 1977 at two Ministry of the Environment monitoring sites in Thunder Bay.

Month	Days of data	Number of readings for concentrations of:				Maximum value	
		0-4	5-10	11-14	>15	Hourly	Daily

Station 63012							
Jan				no data			
Feb				no data			
Mar				no data			
Apr				no data			
May				no data			
Jun	17	417	0	0	0	2	0
Jul	31	738	3	1	0	11	2
Aug	31	738	1	0	0	7	1
Sep	22	548	1	0	0	7	1
Oct	26	638	0	0	0	1	0
Nov	28	676	0	0	0	0	0
Dec	31	742	0	0	0	3	1
Year	186	4497	5	1	0	11	2

Station 63040							
Jan	20	451	0	0	0	1	0
Feb	26	599	0	0	0	4	0
Mar	23	566	1	0	0	6	1
Apr	27	607	6	0	0	8	1
May	31	674	15	1	0	13	2
Jun	30	703	3	1	0	11	1
Jul	31	735	5	0	0	8	1
Aug	29	695	4	0	0	10	1
Sep	28	691	1	0	0	9	1
Oct	25	619	1	0	0	6	1
Nov	25	620	1	0	0	9	1
Dec	31	743	0	0	0	3	1
Year	326	7703	37	2	0	13	1

TABLE 12. Distribution of sulphur dioxide readings (pphm hourly averages) in 1977 at five Ontario Hydro monitoring sites in Thunder Bay.

Month	Number of readings for concentration categories of:						Maximum value	
	0-4	5-10	11-14	15-20	20-25	>25	Hourly	Daily
Station 63023								
Jan	464	1	0	0	0	0	5	2
Feb			no data					
Mar	17	0	0	0	0	0	< 1	< 1
Apr	708	4	0	0	0	0	8	< 1
May	727	7	3	3	1	1	30	3
Jun	718	0	0	0	0	0	5	< 1
Jul	742	2	0	0	0	0	0	1
Aug	742	1	0	0	0	0	6	< 1
Sep	717	3	0	0	0	0	9	2
Oct	577	1	0	0	0	0	8	2
Nov	179	0	0	0	0	0	1	< 1
Dec	744	0	0	0	0	0	3	1
Year	6335	19	3	3	1	1	30	3
Station 63041								
Jan			no data					
Feb			no data					
Mar	165	6	0	0	0	0	8	1
Apr	601	3	6	2	1	1	28	2
May	280	0	0	0	0	0	4	< 1
Jun	12	0	0	0	0	0	< 1	< 1
Jul	443	3	1	0	0	0	11	< 1
Aug	739	3	0	0	0	0	7	< 1
Sep	717	1	1	1	0	0	16	1
Oct	80	0	0	0	0	0	< 1	< 1
Nov	475	18	0	0	0	0	9	2
Dec	696	42	4	1	0	0	6	2
Year	4208	76	12	4	1	1	28	2

TABLE 12. (continued)

Month	Number of readings for concentration categories of:						Maximum value	
	0-4	5-10	11-14	15-20	20-25	>25	Hourly	Daily
Station 63042								
Jan	743	0	0	0	0	0	4	2
Feb	671	0	0	0	0	0	4	2
Mar	686	2	0	0	0	0	7	1
Apr	669	0	0	0	0	0	4	<1
May	720	3	0	0	0	0	8	1
Jun	709	3	0	0	0	0	8	1
Jul	735	2	0	0	0	0	8	1
Aug	572	1	0	0	0	0	6	<1
Sep	717	2	1	0	0	0	12	<1
Oct	740	2	0	0	0	0	5	1
Nov	718	1	0	0	0	0	6	<1
Dec	733	0	0	0	0	0	4	<1
Year	8413	16	1	0	0	0	12	2
Station 63043								
Jan	742	0	0	0	0	0	2	<1
Feb	664	0	0	0	0	0	2	<1
Mar	703	0	0	0	0	0	4	<1
Apr	716	1	0	0	0	0	17	<1
May	732	2	0	0	0	0	6	<1
Jun	717	0	0	0	0	0	3	<1
Jul	738	0	0	0	0	0	4	<1
Aug	740	0	0	0	0	0	2	<1
Sep	718	1	0	0	0	0	5	<1
Oct	743	0	0	0	0	0	2	<1
Nov	718	0	0	0	0	0	4	<1
Dec	706	0	0	0	0	0	1	<1
Year	8637	4	0	1	0	0	17	<1
Station 63044								
Jan	743	1	0	0	0	0	5	2
Feb	669	0	0	0	0	0	3	1
Mar	686	1	0	0	0	0	5	1
Apr	716	1	0	0	0	0	6	1
May	727	10	2	1	1	0	23	3
Jun	719	1	0	0	0	0	10	1
Jul	739	1	1	0	0	0	10	<1
Aug	739	5	0	0	0	0	10	1
Sep	713	3	0	0	0	0	7	1
Oct	721	3	0	0	0	0	6	2
Nov	505	0	0	0	0	0	3	<1
Dec	705	0	0	0	0	0	4	<1
Year	8382	26	3	1	1	0	23	3

TABLE 13. Distribution of total reduced sulphur readings (ppb, hourly averages) at station 63046, Thunder Bay, 1977.

Month	Days of data	Number of readings for concentrations of:					Maximum value	
		0-10	11-27	28-50	51-100	>100	Hourly	Daily
Jan	31	727	8	0	0	0	15	5
Feb	26	621	12	0	0	0	22	4
Mar	31	734	9	0	1	0	56	9
Apr	30	697	17	0	0	0	20	5
May	29	665	41	1	0	0	44	7
Jun	29	654	36	8	0	0	35	9
Jul	29	657	40	2	0	0	36	6
Aug	5	114	10	0	0	0	27	5
Sep	3	80	2	0	0	0	12	1
Oct	31	672	61	5	0	0	41	12
Nov	23	576	9	0	0	0	15	3
Dec	31	737	4	0	0	0	18	4
Year	298	6934	249	16	1	0	56	12

TABLE 14. Directional distribution of hourly average readings of total reduced sulphur (TRS) at station 63046, Thunder Bay, 1977.

Wind direction ^a	Number of hours when TRS was monitored	Average concentration (ppb) when TRS was monitored
N	32	3
NNE	33	2
NE	25	2
ENE	27	2
E	37	2
ESE	18	2
SE	10	3
SSE	10	2
S	48	3
SSW	158	3
SW	533	5
WSW	485	7
W	342	6
WNW	74	5
NW	36	3
NNW	19	2
Calm	382	3

^aMeasured 10 m above ground at Thunder Bay airport.

2. Addition

